

# *Pseudococculina rimula*, a new species (Cocculiniformia: Pseudococculinidae) from off southeastern Brazil

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## ABSTRACT

*Pseudococculina rimula*, new species, is described. It occurs off the state of Rio de Janeiro, in southeastern Brazil, at 350–400 m depth. This is the first report of the genus in the Atlantic Ocean. The main diagnostic characters of the new species are: shell high, lacking radial sculpture; snout flat, somewhat involved by oral lappets; posterior odontophore cartilages connected to anterior one in median line; gonad connected to posterior end of pallial cavity by a gonoduct running transversally and dorsally in visceral mass; sperm duct mostly closed (tubular), prostate located inside right tentacle; sperm duct opening in a subterminal papilla.

*Additional keywords:* Anatomy, southwestern Atlantic, Rio de Janeiro.

## INTRODUCTION

The Cocculiniformia encompasses taxa with an enigmatic set of primitive and derivate features. Its closest groups are yet to be determined, and it is still questionable whether the taxon is monophyletic. They are usually minute, patelliform gastropods living in the deep sea.

Two papers have been published dealing with cocculiniform gastropods found in deep waters off Brazil: Simone (1996) described an addisonioid, and Leal and Simone (2000) named a pseudococculinid. Both papers provided anatomical information, which is vital for understanding the systematics of the group. Further data on western Atlantic cocculiniformians have been provided by McLean and Harasewych (1995) and Leal and Harasewych (1999).

The present paper provides the description of a third Brazilian species, which was collected by an otter trawl off the coast of São Paulo State, in southeastern Brazil.

## MATERIALS AND METHODS

The specimens were dissected using standard techniques, under a stereomicroscope and immersed in fix-

ative. The hard structures (radula and shell) were also examined in a SEM in the Laboratório de Microscopia Eletrônica do MZSP, also using traditional techniques. All drawings were made with the aid of a camera lucida. Abbreviations used in the figures are: **am**, arms; **ap**, aperture of gonoduct; **au**, auricle; **bm**, buccal mass; **br**, subradular membrane; **bs**, blood sinus; **ce**, cerebral ganglion; **cv**, ctenidial vein; **dc**, dorsal chamber of buccal mass; **dd**, duct to digestive gland; **df**, dorsal fold of buccal mass; **dg**, digestive gland; **di**, diaphragm-like septum separating buccal mass from visceral mass; **ef**, esophageal folds; **ep**, epipodium; **es**, esophagus; **et**, epipodial tentacle; **fs**, foot sole; **ft**, foot; **gb**, gonoduct; **gi**, gill; **go**, gonad; **he**, head; **hm**, head muscle; **in**, intestine; **jw**, jaw; **kl**, left kidney; **kr**, right kidney; **ml**–**ms**, extrinsic and intrinsic odontophore muscles; **mb**, mantle edge; **mc**, mouth sphincter; **mf**, mantle fold; **mj**, jaws, buccal, and oral tube muscles; **mo**, mouth; **oe**, anterior odontophore cartilage; **od**, odontophore; **ol**, oral lappet; **ov**, ovary; **pc**, pericardium; **po**, posterior odontophore cartilage; **pp**, papilla of copulatory tentacle; **pt**, prostate; **pu**, pedal ganglion; **ra**, radula; **rn**, radular nucleus; **rs**, radular sac; **rt**, rectum; **sc**, subradular cartilage; **sd**, sperm duct; **se**, chamber originating esophagus and separating odontophore in buccal mass; **sm**, shell muscle; **sn**, snout; **st**, stomach; **te**, cephalic tentacle; **tg**, integument; **tp**, copulatory right cephalic tentacle; **ts**, testis; **ve**, ventricle; **vm**, visceral mass.

Institutional abbreviations used are: MNHN, Muséum National d'Histoire Naturelle, Paris, France; MNRJ, Museu Nacional, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil; MZSP, Museu de Zoologia da Universidade de São Paulo, São Paulo, Brazil.

## SYSTEMATICS

Genus *Pseudococculina* Schepman, 1908

**Type species:** *Pseudococculina rugosoplicata* Schep-

man, 1908 by subsequent designation, Wenz, 1938, p. 150.

*Pseudococculina rinula* new species

(Figures 1–30)

**Diagnosis:** Shell high, anterior region strongly concave. Sculpture of concentric undulations and threads. Snout flat, surrounded by oral lappets. Jaw plates thin. Posterior odontophore cartilages connected to anterior one along median line. Gonad connected to posterior end of pallial cavity by a gonoduct that runs transversally and dorsally in visceral mass. Sperm duct mostly closed (tubular) opening in a subterminal papilla, prostate inside right tentacle.

**Description:** Shell (Figures 1–4, 6–10) patelliform, length up to 3 mm, high (height 60–70% of length), white, relatively thick. Protoconch (Figures 6, 7) with one whorl, planispiral, coiled towards ventral region, with a papilla-like projection on each side oriented along direction of coiling; outer surface smooth, opaque. Teleoconch opaque, sculpture of strong, commarginal growth lines and threads. Apex high, curved ventrally and posteriorly, situated along median line of shell, closer to posterior region. Anterior region convex, posterior region weakly concave. Inner surface glossy. Muscular scar horseshoe-shaped (concavity anterior) (Figures 9, 10), narrow posteriorly, thick anteriorly; anterior ends curved toward dorsal and posterior regions.

**Head-foot (Figures 2, 14–15):** Head protruded, occupying about 1/3 of total volume of head-foot. Snout well developed, somewhat flat, edges broad, flat, extending externally (Figures 14–17). Oral lappets (lateral expansions on snout) large, covering most of anterior half of animal body. Cephalic tentacles asymmetrical, right tentacle 50 % larger than left tentacle (Figures 16, 17), acting as copulatory organ (details below). Foot sole, or mesopodium, flat, thick, occupying most of ventral surface (Figures 2, 14); anterior edge with a very narrow and shallow furrow. Epipodium about ¼ of shell width, forming a flat flap, inserted between mesopodium and mantle; free edge with 2 pairs of tentacles on each side, inner tentacles longer and slender, outer tentacles shorter and broader (Figure 18). Shell muscle horseshoe-shaped, posterior region narrow (Figure 15), right half broader and thicker than left half; shell muscle gradually becomes thicker toward anterior region; on posterior region of head, shell muscle turns abruptly, first in dorsal, then in posterior direction. Paired head muscles originate as continuations of the antero-dorsal end of shell muscle (Figure 15); right muscle slightly flatter and broader than left muscle; both run toward mid-anterior region immersed in tegument, forming a V-shaped structure, both muscles attach, spreading out, into median region of head wall (Figure 20).

**Mantle Organs (Figures 5, 16, 17, 19):** Pallial cavity shallow, shorter than 1/3 of animal length. Mantle edge

simple, weakly bilobed. Gill relatively small, with about 15–20 filaments, left end close to inner edge of left branch of shell muscle; gill narrows gradually towards right, curving posteriorly, running between mantle and right branch of outer edge of shell muscle, up to about mid-length of animal. Gill filaments low, triangular, rod narrow, located in anterior edge. Ctenidial vein contouring anterior part of gill edge. Low and long glandular fold present left half of gill and mantle edge. Rectum and pericardial structures located in posterior region of roof of pallial cavity, just posterior to gill, as described below.

**Visceral Mass (Figure 15):** Compressed ventrally by foot and shell muscle. Stomach occupying central region, surrounded by digestive gland and intestine. Gonad located in postero-ventral region, between two intestinal loops. Digestive gland pale-brown, with small spots forming a net-like mosaic. Gonad cream-colored. A thin diaphragm-like membrane separates buccal mass from remaining posterior structures (Figure 20, di); this membrane inserted in haemocoel surrounding buccal mass; only esophagus, anterior aorta and visceral nerves pass through membrane.

**Circulatory and Excretory Systems (Figures 5, 15, 19):** Pericardium and both kidneys flattened dorso-ventrally, situated in roof of pallial cavity, between gill and posterior end of this cavity. Pericardium broad, about twice heart area, located between left end of gill and left branch of shell muscle. Auricle triangular, its right side attached to pericardium cavity, contouring gill end with a concavity; insertion of ctenidial vein somewhat broad in its anterior region; connection with ventricle narrow, posterior. Ventricle small and thick, muscular, located posterior to auricle, close to rectum. Aorta very small, posterior and at left from ventricle. Left, anterior kidney elliptical, flattened, solid; located between gill posterior region and rectum, touching this latter. Right, posterior kidney, longer and narrower, situated on other side of rectum at same level of left kidney, extending little beyond it toward right.

**Digestive System (Figures 20–30):** Mouth a transversal slit located on antero-ventral region of snout (Figures 14, 20). Buccal sphincter (Figure 23, me) well-developed and thick. Buccal mass very large, about half of haemocoel length. Oral tube very short, broad, walls thick, muscular; inner surface with low transversal folds. Buccal mass V-shaped, odontophore and esophagus representing respectively ventral and dorsal branches. Inner surface of dorsal wall of buccal mass with pair of broad dorsal folds (Figure 28) that unite anteriorly, edges higher in their mid-region. Dorsal chamber (dc) (delimited by both dorsal folds) relatively deep and broad; inner surface smooth. Jaw plates very thin, color pale brown; anterior end rounded, situated just anterior to connection of dorsal folds (Figures 21, 23, 28); posterior end inconspicuous, gradually weaker in posterior direction up to posterior level of odontophore insertion. Odonto-



**Figures 1–10.** *Pseudococculina rimula* new species. 1–3. Dorsal, ventral, and lateral (left) views of holotype prior to extraction of specimen from shell. Scale bar = 0.50 mm. 4. Paratype, young specimen, SEM (dorsal view, scale bar = 0.20 mm). 5. Roof of pallial cavity and adjacent portion of pericardial structures, ventral view, light micrograph (carmine stain). Scale bar = 0.25 mm. 6. Protoconch, SEM (dorsal view, scale bar = 0.05 mm). 7. Same, lateral (right side) view, scale bar = 0.02 mm. 8–10. Paratype adult specimen, SEM (lateral (left side), oblique (right), and ventral views, scale bar = 0.50 mm).



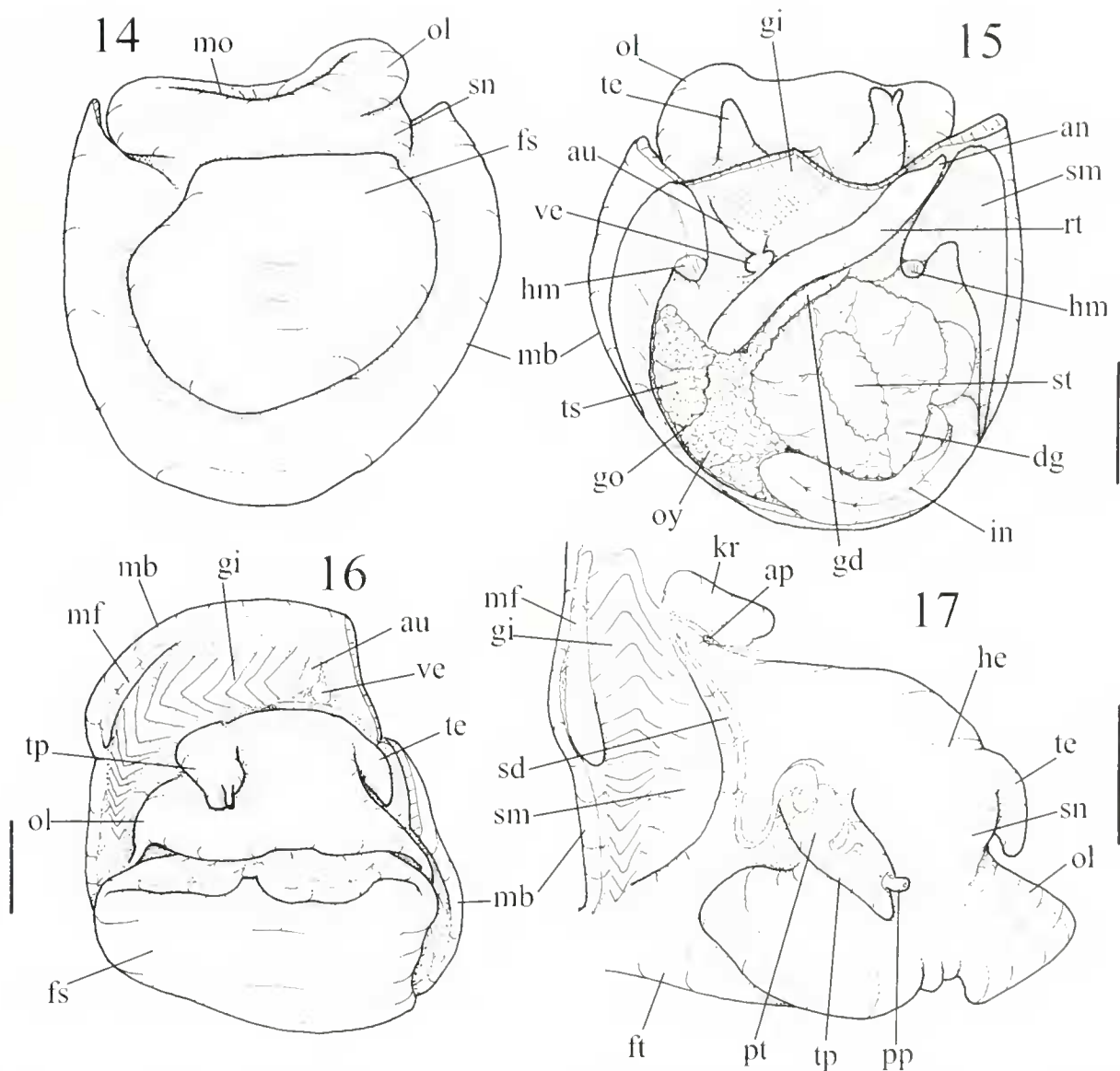


Figures 11–13. *Pseudococculina rimula* new species, SEM of radular teeth. Scale bars = 50, 10, and 10  $\mu\text{m}$  respectively.

phore pear-shaped, occupying most of buccal mass volume. Odontophore muscles (Figures 23–30): **m1**, series of small and thin muscles connecting buccal mass to adjacent inner surface of haemocoel, more concentrated around mouth; **m1a**, pair of narrow jugal muscles, originating in antero-ventral region of inner surface of snout, running in postero-dorsal direction and inserted in ventral-posterior region of odontophore on lateral region of posterior cartilages; **mj**, pair of muscles moving oral tube and jaws, originating in mid-ventral region of odontophore, contouring anterior edge of posterior cartilages, running toward anterior region, insertion spread out between oral tube and dorsal wall of buccal mass; **m3**, single transversal muscle, very thin, located just ventral to origin of esophagus in buccal mass, uniting both sides of postero-dorsal surface of odontophore; **m4**, large pair of dorsal tensor muscles of subradular membrane, originating in latero-ventral surfaces of anterior cartilages, running toward dorsal region, surrounding these cartilages and covering most of their surfaces, inserting along subradular membrane in its exposed (functional) region; a short portion also originates from posterior cartilages, in their latero-ventral surfaces; **m5**, pair of ventral tensor muscles of radula, originating in posterior edge of posterior cartilage, running toward meso-dorsal region, contouring posterior edge of anterior cartilage, inserting in ventral surface of radular ribbon in posterior half of its exposed region; **m5a**, a continuation of **m4**; **m6**, horizontal muscle, single thin, uniting both anterior cartilages along their inner ventral edges; **m8**, pair of approximator muscles of cartilages, connects anterior and posterior pairs of cartilages, originating from relatively large areas of ventral surface of anterior cartilages, inserting in anterior and inner edge of posterior cartilage; **m11a**, pair

of narrow ventral tensor muscles of radula, originating in median corner of posterior cartilages, running toward anterior region on ventral surface of odontophore close to its median line, inserting in ventral end of subradular membrane. Other odontophore non-muscular structures: **oc**, anterior pair of cartilages, elliptical, flat, soft, slightly shorter than odontophore length, anterior end broadly pointed, posterior end blunt; **po**, posterior pair of cartilages, length about  $\frac{1}{4}$  of anterior cartilages, somewhat circular, flat, outer surface convex, inner surface concave, covering postero-external surface of anterior cartilages; both pairs of cartilages fused with each other along their median corner (Figure 29); **br**, subradular membrane, included in radular sac and extending beyond it, covering exposed surface of odontophore within buccal cavity, connecting with lining of oral cavity; **sc**, subradular cartilage, a thin, transparent but strong membrane connected to subradular membrane, covering part of exposed portion of odontophore in buccal cavity (Figure 24). Radular sac with about same length of odontophore, curved in its middle portion, located in middle-right region of visceral mass (Figures 20, 21). Radular nucleus covered by a conspicuous membrane surrounding a blood sinus (Figure 23), located in left-ventral region of visceral mass.

Radula asymmetrical, teeth rows offset by  $\frac{1}{2}$  row height; rachidian teeth apparently in level of right half rows. Radular teeth (Figures 11–13): 1) Rachidian antero-posteriorly long, laterally narrow; base flat, with edges slightly elevated; distal cutting edge concave, low, curved inward; 2) Lateral teeth in five pairs: 2a) first lateral tooth triangular, as long as rachidian, base broad, flat, slanted; remaining region narrowing gradually; tip broadly pointed, curved inward; 2b) second, third, and

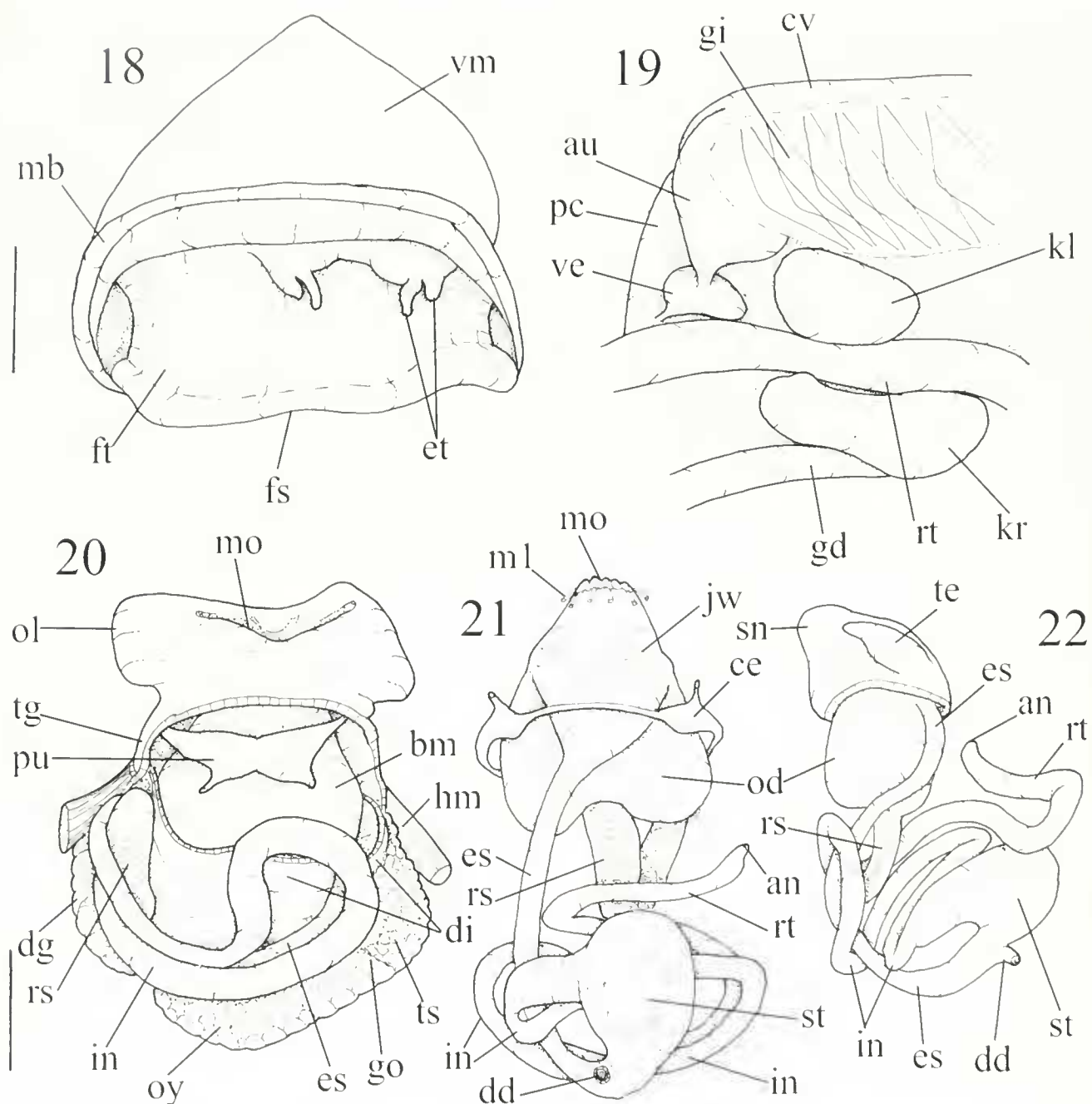


**Figures 14–17.** *Pseudococculina rinula* new species, anatomy. **14.** Head-foot and adjacent mantle edge, ventral view. **15.** Whole animal extracted from shell, dorsal view, roof of pallial cavity partially removed. **16.** Whole animal, anterior view, roof of pallial cavity sectioned at on right side then deflected to expose inner structures. **17.** Head and adjacent pallial structures, anterior (but slightly from right side) view, roof of pallial cavity deflected. Scale bars = 0.5 mm.

fourth lateral teeth equal to each other, first tooth slightly smaller, approximately half size of rachidian, situated at same level of broader region of first lateral tooth; base somewhat narrow and short, situated at some distance from adjacent teeth in same row; lateral edge high, curved obliquely, tip sharply pointed, high, curved inward; 2c) outermost lateral tooth as long as rachidian, thick, cylindrical; base narrow, increasing gradually towards distal end; distal end expanding abruptly, with three subterminal, low, inward-turned, stubby cusps located on thicker region; concave region located opposite to cusps, nested in base of corresponding tooth of adjacent row; 3). Marginal teeth in 60–65 pairs, all similar;

inner teeth larger, gradually decreasing toward edge of ribbon; larger teeth about  $1.5 \times$  rachidian length; base slender and flat; middle region long, rod-like, tall, straight; tip strongly curved inwards, apex sharply pointed, preceded by 6–8 pairs of small, slender, pointed cusps along both sides of broader area of tip.

Origin of esophagus marked by a sudden constriction of dorsal chamber of buccal mass (Figures 21–23). Esophagus narrow, inner surface with pair of low and narrow longitudinal folds (Figure 25), a continuation of dorsal folds of buccal mass. Esophagus runs contouring postero-lateral left surface of odontophore toward postero-ventral region, beyond which it surrounds mid-ven-



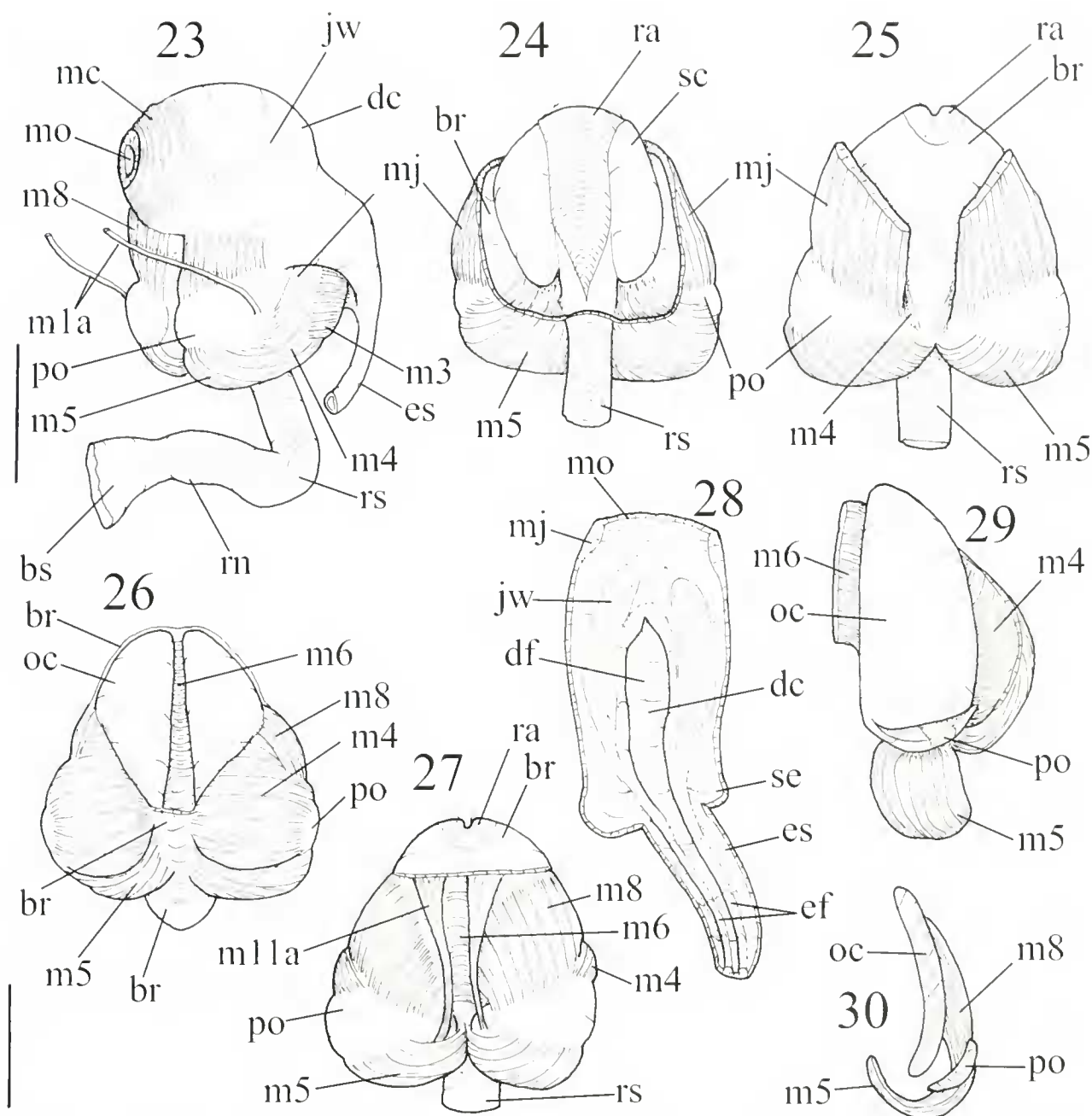
Figures 18–22. *Pseudococculina rinula* new species, anatomy. 18. Whole animal extracted from shell, posterior view, mantle edge deflected. 19. Posterior region of pallial roof, dorsal view, depicted by transparency. 20. Head, ventral view, foot removed, haemocoel exposed with inner structures as *in situ*. 21. Digestive tube as *in situ*, dorsal view, structures posterior to esophagus slightly deflected. 22. Same, lateral (left side) view. Scale bars = 0.5 mm.

tral surface of foot along a broad curve; after this esophagus runs toward mid-dorsal region, in direction of shell apex, where it inserts in stomach (Figures 21, 22).

Stomach somewhat narrow and long, located transversally in middle region of visceral mass; its dorsal half broader and spherical (Figures 21, 22), with esophageal connection located in its posterior region. Duct to digestive gland narrow, inserted in left region of esopha-

geal connection. Stomach ventral half flattened and long, narrowing gradually. Inner surface of stomach iridescent, greenish. Digestive gland surrounding stomach for most of its area. Intestinal loops complex, as shown in Figures 21 and 22.

Intestine originates at flattened portion of stomach and is included in mid-ventral region of visceral mass. Intestine is convoluted; after its origin in stomach it runs



**Figures 23–30.** *Pseudococculina rimula* new species, foregut. **23.** Whole animal, lateral (left side), but slightly ventral view. **24.** Odontophore, dorsal view. **25.** Same, ventral view. **26.** Odontophore, dorsal view, radula and subradular cartilage removed, both anterior cartilages deflected. **27.** Odontophore, ventral view, first layer of muscles and membranes removed. **28.** Dorsal wall of buccal mass and anterior esophagus, ventral-inner view. **29.** Odontophore, dorsal view, detail of its right side with most muscles deflected for showing right cartilages. **30.** Same representation of a transversal section. Scale bars = 0.5 mm.

obliquely toward dorso-lateral region, surrounding ventral surface of stomach; in latero-dorsal right region of visceral mass intestine describes broad curve toward postero-ventral region, runs down to mid-ventral region of visceral mass, touching inner surface of foot and surrounding middle portion of esophagus; in this region intestine curves broadly, returning to its previous location.

running parallel to it but in opposite direction; in latero-dorsal right region of visceral mass intestine describes yet another broad loop ventral to the previous loop, turning along horizontal plane toward left; in latero-anterior left region of visceral mass it curves abruptly toward right region, surrounding odontophore; this last loop runs obliquely toward latero-anterior right region



of roof of pallial cavity. Anns located on latero-posterior right region of roof of pallial cavity roof (Figure 15).

**Reproductive System (Figure 15):** Gonad located in latero-posterior left region of visceral mass, just dorsal to shell muscle. Testis more anterior, with smooth, uniform surface. Ovary occupying mid-posterior region of gonad, with granulose surface. Gonad with short projection running along right edge of rectum. Gonad gradually becomes a gonoduct along middle portion of rectum. Gonoduct with thin, transparent walls, running obliquely on surface of visceral mass alongside rectum; opens in pallial cavity posterior end, posterior to right (posterior) kidney (Figures 15, 19). A shallow furrow runs from this aperture, contouring latero-posterior right corner of pallial cavity to aperture of sperm duct (Figure 17). Posterior aperture of sperm duct directed to left, protected by a pair of diverging folds. Sperm duct very narrow, thin-walled, entirely closed (tubular), running along right edge of floor of pallial cavity to an area anterior to right tentacle, where it folds abruptly toward left and penetrates base of right tentacle. Sperm duct runs along right cephalic tentacle, its basal 2/3 intensely coiled and with thick glandular walls, thicker in its middle portion, then gradually narrows, its distal 1/3 very narrow and almost straight (Figure 17). Sperm duct opening in tip of subterminal papilla; papilla cylindrical, short, nested in a small concavity (which may indicate possible ability to retract).

**Central Nerve System (Figure 21):** Ganglia relatively small and separated from each other. Paired cerebral ganglia relatively distant from each other, located in medially in latero-dorsal region of buccal mass. Pedal ganglia relatively close to each other, situated between middle and anterior portions of ventral surface of buccal mass (Figure 20). Remaining ganglia not studied in details.

**Shell Measurements (Length, Width, and Height in mm):** MZSP 35319 paratype #4: 3.0 by 2.5 by 1.7; #5: 3.3 by 2.7 by 1.7; #6: 3.1 by 2.6 by 1.9.

**Type Material:** Holotype MZSP 35318; Paratypes: MZSP 35319, 12 specimens; MNRJ 5965, 3 specimens (1 without shell); MNHN, 3 specimens (1 without shell), all from type locality, otter trawl, C. Magenta leg., Apr. 2002.

**Type Locality:** Off southern Rio de Janeiro State, Brazil, 350–400 m depth, rocky bottom.

**Distribution:** Known only from type locality.

**Habitat:** Rocky bottom.

## DISCUSSION

The generic allocation of the new species is mainly based on the diagnosis of the genus provided by Marshall (1955: 522 and Haszprunar 1988: tab. 2, p. 177), with addition of further data from other authors (e.g., Mc-

Lean and Harasewych, 1995). *Pseudococculina rimula* appears to be the first occurrence of the genus in the Atlantic.

*Pseudococculina rimula* differs from the remaining congener species in having a high shell and by lack of radial sculpture. *Pseudococculina rimula* resembles *P. gregaria* Marshall, 1955, from New Zealand, but differs by having higher shell, narrower radular rachidian, and by different characters of the copulatory right tentacle, such as uncoiled sperm duct and absence of papilla.

The anatomy of the new species fits the general plan described for the family (Haszprunar, 1987, 1988). Anatomical characters defining the family are gonad divided into testis and ovary and right cephalic tentacle as copulatory organ. However, the new species possesses some peculiarities, as, e.g., the apparent absence of salivary glands (glands are sometimes poorly developed in cocculiniform limpets), the ventricle free from the rectum, the presence of a short opened portion in the sperm duct running on pallial floor; and the presence of a visceral gonoduct. The gonoduct has been regarded as a modification of the right kidney, but, if so, it is only part of the kidney underwent modification, since there is a detectable right kidney. The presence of a very long right kidney, in the *P. rimula* gonoduct, is found in the comparable topology of *Yaquinaabyssia careyi* McLean, 1988 (Haszprunar, 1988: fig. 2). The muscles of the odontophore differ from those of *Kurilabyssia venezuelensis* (McLean, 1988; Haszprunar, 1988: fig. 3) in lacking oral tube muscle and dorsal retractor of cartilages, and by a greater development of the buccal sphincter; differ from those of *Coccopygma hispida* Marshall, 1986 (Haszprunar, 1987: fig. 3) in lacking buccal dilators and ventral protractors of cartilage, and also by the great development of the buccal sphincter; differ from *Cocculina nipponica* Kuroda and Habe, 1949 (Sasaki, 1995: fig. 70) in lacking the pair of ventral tensor muscles of radular sac, lacking the pair of median protractor muscle of subradular membrane, and in having the pair of posterior cartilages.

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